Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Part 15 of the	)	ET Docket No. 99-231
Commission's Rules Regarding	)	
Spread Spectrum Devices	)	
	)	
	)	

SECOND REPORT AND ORDER
(Proceeding Terminated)

Adopted: May 16, 2002 **Released: May 30, 2002**

By the Commission: Commissioner Martin issuing a statement.

INTRODUCTION

1. By this action, we amend Part 15 of the Commission's rules to provide for the introduction of new digital transmission technologies, to eliminate unnecessary regulations for spread spectrum systems, and to improve spectrum sharing by unlicensed devices operating in the 915 MHz (902 - 928 MHz), 2.4 GHz (2400 - 2483.5 MHz), and 5.7 GHz (5725 – 5850 MHz) bands. Specifically, this Second Report and Order revises Section 15.247 of the Commission's rules to allow new digital transmission technologies and direct sequence spread spectrum systems to operate under the same rules in the 915 MHz, 2.4 GHz, and 5.7 GHz bands.[1] We also modify the rules to remove the requirement that direct sequence spread spectrum systems must demonstrate at least 10 dB of processing gain. This Second Report and Order also modifies the rules for frequency hopping spread spectrum systems operating in the 2.4 GHz band to reduce the amount of spectrum that must be used with certain types of operation. We take these actions to facilitate the continued development and deployment of new wireless devices for businesses and consumers.

BACKGROUND

2. Part 15 of the Commission's rules provides for the operation of unlicensed devices. As a general condition of operation, Part 15 devices may not cause any harmful interference to authorized services and must accept any interference that may be received.[2] Section 15.247 contains rules governing the operation of spread spectrum devices in the 915 MHz, 2.4 GHz, and 5.7 GHz bands. Operation under

[1] 47 C.F.R. § 15.247

[2] 47 C.F.R § 15.5.

these rules is limited to frequency hopping and direct sequence spread spectrum systems. Spread spectrum modulation reduces the power density of the transmitted signal at any frequency, thereby reducing the possibility of causing interference to other signals occupying the same spectrum. Similarly, at the receiver end, the power density of interfering signals is minimized, making spread spectrum systems relatively immune to interference from outside sources. In frequency hopping systems, an information signal, usually a data stream, modulates a radio frequency carrier that quickly moves from frequency to frequency in concert with a receiver.[3] In direct sequence systems, the information data stream is combined with a high speed digital spreading code that is used to modulate a radio carrier, producing a radio signal that has a bandwidth covering anywhere from 1 to 100 megahertz.[4] Both frequency hopping and direct sequence systems are permitted to use output powers of up to 1 watt in the above bands, however, most devices use lower power for various design reasons, such as conserving battery life.[5]

3. In the *Further Notice of Proposed Rule Making* (*Further Notice*) in this proceeding, we proposed to allow alternative digital technologies to operate in the bands formerly reserved for frequency hopping and direct sequence spread spectrum systems.[6] Additionally, we proposed to eliminate the 10 dB processing gain requirement for direct sequence spread spectrum systems. Finally, we proposed to permit frequency hopping systems in the 2.4 GHz band to use as few as fifteen hopping channels, regardless of the hopping channel bandwidth utilized, provided that the output power does not exceed 125 mW and the device uses adaptive hopping techniques.[7] Under this proposal, devices that use 75 channels or more would still be allowed to operate with output power up to 1 Watt. Twenty-three parties filed comments in response to the *Further Notice* and thirteen parties filed reply comments. A list of parties is included in Appendix A.

DISCUSSION

4. The Commission's spread spectrum rules have been a tremendous success. A wide variety of devices have been introduced under these rules for business and consumer use, including improved cordless telephones and computer local area networks. Moreover, the past few years have witnessed the development of industry standards, such as IEEE 802.11b, Bluetooth, and Home RF, that promise to greatly expand the number and variety of devices that will operate in the 2.4 GHz band.[8] This will provide the capability necessary for the introduction of wireless headsets and computer connections

[3] *See* 47 C.F.R. § 2.1(c).

[4] *Id.*

[5] Frequency hopping systems that use fewer than 75 hopping channels are limited to 125 mW output power. *See* 47 C.F.R. § 15.247(b).

[6] *Further Notice of Proposed Rule Making and Order, ET Docket 99-231*, 16 FCC Rcd. 10036 (2001).

[7] *Id.* at paragraph 13.

[8] These operating standards provide manufacturers with guidance for developing spread spectrum devices for the 2.4 GHz band. The IEEE 802.11b standard applies to direct sequence devices, while the Bluetooth and Home RF standards apply to frequency hopping devices.

for cellular and PCS phones, wireless computer peripherals such as printers and keyboards, and a host of new wireless Internet appliances that will use all of the spread spectrum bands.

5. Since the time the spread spectrum rules were first introduced some 15 years ago, we have amended those rules several times to accommodate technology developments and promote new and innovative use of the 915 MHz, 2.4 GHz, and 5.7 GHz bands.[9] Over the years, the data rates achievable by spread spectrum devices have increased from a few kilobits per second to over 20 megabits per second. These high data rates were not envisioned when the rules were first drafted. Moreover, the original rules were crafted in a manner to highlight the interference immunity characteristics of spread spectrum devices, even at the expense of higher speeds. Our current rules contain provisions that unnecessarily restrict system designs that could otherwise achieve data rates of more than about 20 megabits per second.

6. We initiated this proceeding to provide for the continued development of technologies that spread an RF signal across a wide band of spectrum. The rule changes adopted in this Second Report and Order are intended to provide manufacturers with the flexibility to design and market a more diverse set of products which are able to operate efficiently in the unlicensed bands. Manufacturers will have the freedom to design products that fit the various needs of users who may have differing requirements for data speeds and interference resistance. The rule changes will also allow for greater sharing of the spectrum by all devices in the 2.4 GHz band by removing regulatory barriers to the introduction of new non-interfering technologies.

A. Digital Systems

7. In the *Further Notice*, we observed that a number of new digital modulation technologies have been developed that have spectrum characteristics similar to direct sequence spread spectrum systems. That is, the digital systems spread their transmitted energy across a wide bandwidth, thereby minimizing the amount of energy transmitted in any one portion of the occupied frequency band. Therefore, such digital modulation systems may exhibit no more potential to cause interference to other devices than direct sequence systems. However, because digital modulation systems do not meet the Commission's definition of a spread spectrum system, they have not been allowed to operate under Section 15.247.[10] In the *Further Notice*, we proposed to amend Section 15.247 to provide for use of these new digital technologies in the 915 MHz, 2.4 GHz, and 5.7 GHz bands. We invited comment on whether these technologies should be allowed to operate at the same power levels as direct sequence spread spectrum systems, specifically 1 Watt maximum output power with a maximum power spectral density of 8 dBm per 3 kHz.[11] We also invited comment as to whether the flexibility we proposed for digitally modulated systems warranted a reduction in permitted power levels to reduce the likelihood of any adverse impact on other systems operating in this spectrum, similar to the reduced power levels adopted earlier for wide-band frequency hopping systems.[12] We further asked if we should make changes in the

[9] *First Report and Order, GEN Docket 81-413*, 1 FCC 2nd 419 (1985), 58 RR 2nd 251 (1985).

[10] The Commission defines a direct sequence system as a spread spectrum system in which the carrier has been modulated by a high speed spreading code and an information data stream. The high speed code sequence dominates the "modulating function" and is the direct cause of the wide spreading of the transmitted signal. *See* 47 C.F.R. § 2.1(c).

[11] *See* 47 C.F.R. § 15.247(b)(1) and (d).

[12] *See First Report and Order* in ET Docket 99-231, 15 FCC Rcd 16244(2000).

power level adjustments for point-to-point operation in Section 15.247(b)(3) if the allowed power for digitally modulated systems was reduced.[13] Finally, we noted that the proposals for new digital devices are similar to the rules for Unlicensed National Information Infrastructure (U-NII) devices contained in Subpart E of Part 15, and sought comment on whether these new digital technologies could be accommodated under those rules.[14] We noted that, in order to accommodate these devices, the U-NII rules would need to be amended to include the 915 MHz and 2.4 GHz bands. Additionally, the upper limit of the 5.725 - 5.825 GHz U-NII band would also need to be expanded to 5.850 GHz in order to realign the standards with those presently permitted under Section 15.247.

8. The commenting parties generally support the proposal to permit the use of alternative digital modulation techniques in the 915 MHz, 2.4 GHz, and 5.7 MHz bands.[15] However, there was a diversity of opinion as to the output power and spectral density levels at which these devices should be allowed to operate. Several parties express support for allowing digital technologies to have the same maximum proposed power level and power spectral density limits as direct sequence spread spectrum systems.[16] Wi-LAN, Inc. ("Wi-LAN"), notes that, because digital technologies such as OFDM and direct sequence spread spectrum generate similar spectral signatures, allowing other digital systems the same output levels as spread spectrum will not generate any more interference.[17] They state that devices already authorized for use and meeting these requirements have not caused interference in the bands. Similarly, 3Com Corporation, Clearwire Technologies, Inc., InterWAVE Communications Inc., LinCom Wireless, Inc., Symbol Technologies, Inc, and Vocollect, Inc. ("Joint Commenters") in their collective response, advocate operation at 1 Watt.[18] They state that a victim receiver is affected primarily by the amount of incoming RF energy, and much less (if at all) by the specific form of modulation. Accordingly, Joint Commenters argue that digital systems can be authorized under the same regulations at direct sequence systems with no significant increase of interference to other users.[19] Likewise, the Information Technology Industry Council supports the proposed limits on the basis that digital technologies do not have more potential to cause interference than direct sequence spread spectrum systems.[20] Proxim, Inc. ("Proxim") also adds support for allowing digital technologies to operate at the

[13] *See* 47 C.F.R. § 15.247(b)(3).

[14] *See* 47 C.F.R. Subpart E – Unlicensed National Information Infrastructure Devices. This rule section provides for the operation of intentional radiators which use wideband digital modulation techniques in the 5.15 - 5.35 GHz and 5.725 – 5.825 GHz bands. U-NII devices operating in the lower frequency bands are restricted to output powers of between 50 mW to 250 mW. Devices operating in the 5.725 -5.825 GHz U-NII band are allowed 1 Watt output power, the same output power allowed for spread spectrum devices in the 5.725 – 5.850 GHz band. However, digital systems operating under the U-NII rules at the full 1 Watt are required to have a wider bandwidth than a spread spectrum system operating at 1 Watt. *See* 47 C.F.R. § 15.407(a)(3).

[15] *See, e.g.,* comments of Proxim, Inc. and Wi-LAN, Inc., and reply comments of Information Technology Industries Association.

[16] *See, e.g.*, comments of Wi-LAN, Inc., Information Technology Council, and Proxim, Inc.

[17] Wi-LAN, Inc. comments at pages 2-4.

[18] *See* Joint Comments at page 3.

[19] Joint Commenters at page 4.

[20] *See* ITI reply comments.

1 Watt, 8 dBm/3 kHz limits.[21] Proxim submits a technical statement which demonstrates that, in some cases, it is preferable to employ one higher-powered transmitter as opposed to multiple lower powered transmitters to cover a given area. Proxim states that while system designers always have the option and incentive to use a lower power to cover an area, the only result that arises from a mandatory lowering of the output power for digital transmission systems is to require more devices in areas where fewer, at higher power, could suffice.[22]

9. The Wireless Communications Association, International, Inc. ("WCA") supports the proposed 1 Watt output power but suggests limiting power spectral density to 22 dBm/MHz.[23] It states that because the rules for direct sequence spread spectrum require the digital signal to be spread by a pseudo random code, the power spectral density is significantly lower than that achieved with normal modulations. It states that all modulations in compliance with the IEEE 802.11 direct sequence spread spectrum specification, if using the full output power of 1 Watt, would have a peak power spectral density of 20 dBm/MHz and a bandwidth of 22 MHz. WCA notes that the power levels proposed in the *Further Notice* are based on digital transmissions with the same characteristics as direct sequence systems. It therefore submits that power spectral density should also be limited to the levels of direct sequence devices. The IEEE Project 802™, Local and Metropolitan Area Networks Standards Committee ("IEEE 802") proffers the same argument and states that digital transmission systems could heavily interfere with currently deployed direct sequence spread spectrum systems if allowed to operate at 8 dBm/3 kHz.[24]

10. Some parties express concern that, if digital devices are allowed to operate at 1 Watt and power spectral density of 8 dBm/3 kHz, the devices would cause interference to incumbent spread spectrum systems.[25] They believe that, because digital systems are less immune to interference, they will tend to operate at higher powers and thus cause interference to existing devices. Accordingly, several parties suggest alternative operating conditions for devices using digital modulation techniques, such as lower output power or lower power spectral density, to ensure that energy is evenly spread. For example, Agere Systems ("Agere") argues that there is no conclusive proof that digital modulation systems can operate at 1 Watt with power spectral density limited to 8 dBm/3 kHz without causing interference.[26] For that reason, Agere suggests that the Commission limit digital modulation systems to 125 mW maximum power output, with power spectral density limited to 10 dBm/MHz. Agere submits a technical showing which demonstrates that digital systems would operate satisfactorily in a number of configurations at these levels. Agere notes that its proposed conditions would discourage narrowband operation while allowing sufficient operating margin for digital systems.[27] Similarly, Intersil Corporation ("Intersil") states that the 1 Watt maximum power proposal could lead to a proliferation of inefficient transceivers operating at high power levels. Intersil suggests that digital systems be subject to the same operating

[21] *See* Proxim reply comments at pages 5-7.

[22] *Id*. at page 6.

[23] WCA comments at page 2.

[24] *See* IEEE 802 comments at page 6.

[25] *See, e.g.*, comments of Adtran, Inc., Intersil Corporation, and The Wireless Communications Association International, Inc.

[26] *See* Agere comments at page 8.

[27] *Id*.

conditions as U-NII devices in the 5.25 – 5.35 GHz band.[28] Those devices are generally limited to an output power of 250 mW or less, with power spectral density not exceeding 11 dBm per 1 MHz. Apple Computer, Inc. ("Apple") notes that the proposed regulations would permit a digital system to operate at a full 1 Watt transmitter output power in a relatively narrow bandwidth of 500 kHz. Apple says that this would pose a serious interference threat to existing networks using the 802.11b protocol. One option, according to Apple, would be require new digital systems to operate under the conditions outlined in the European Telecommunications Standards Institute ("ETSI") rules for direct sequence spread spectrum and other forms of modulation. The ETSI rules limit the power spectral density of these devices to 10 dBm/MHz.[29]

11. Based on analysis of the record, we conclude that systems using digital modulation techniques can operate under the same rules as direct sequence spread spectrum devices in the 915 MHz, 2.4 GHz, and 5.7 GHz band without posing additional risk of interference. Therefore, we will remove any regulatory distinction between direct sequence spread spectrum systems and systems using other forms of digital modulation. We will amend Part 15 to replace references to "direct sequence spread spectrum" with the term "digital modulation" and permit all types of digitally modulated systems to be regulated under Section 15.247.[30] This change will permit the authorization of newly developing high data rate technologies.

12. We find that some commenters' concerns that digital devices will operate inefficiently or at very high power levels resulting in interference are unfounded. We note that although direct sequence systems are permitted up to 1 Watt output power and 8 dBm/ 3 kHz power spectral density, many of such devices operate at much lower levels, depending on their application. For example, a search of the Commission's equipment authorization database reveals that many devices operate at output power levels in the range of 70-500 mW, depending on the intended use. Power spectral density levels are typically in the range of -10 dBm/3 kHz to 5 dBm/3 kHz. Generally, indoor devices use power levels much lower than 1 Watt because transmission distances are relatively short. Similarly, devices that are used for mobile applications tend to operate at low power levels in order to achieve maximum battery life. Additionally, manufacturers must also ensure that emissions are at levels low enough to prevent users from being exposed to excessive levels of radiofrequency radiation.[31] We find no evidence to indicate that these same conditions would not apply to new digital devices.

13. We also believe that manufacturers will take into consideration trade-offs in performance from using digital technologies instead of direct sequence spread spectrum technology. Some digital systems that are capable of delivering high data rates may be more vulnerable to receiving interference than conventional direct sequence systems. Manufacturers will have the flexibility to determine whether increased interference immunity or higher data speed is needed under different applications. However, there is no evidence that new digital systems are more likely to operate in a fashion to cause interference

[28] Intersil comments at page 6.

[29] *See* Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment in the 2,4 GHz ISM band and using spread spectrum modulation techniques; Part 1: Technical characteristics and test conditions, ETSI EN 300 328-1, V1.2.2.

[30] "Digital modulation" in the context of 47 C.F.R. §15.247 will have the same meaning as defined in 47 C.F.R. §15.403(b).

[31] *See* 47 C.F.R. § 15.247(b)(4).

to incumbent technologies. As the technical showings from both Agere and Proxim demonstrate, digital systems may be configured in a number of ways with varying output levels, yet have the same interference potential. Therefore, we find that requiring reduced power levels or power spectral density levels, as suggested by some parties, would not be necessary to ensure operation in a non-interfering manner. Indeed, such action would be counterproductive to our goal of minimizing the regulatory restrictions on Part 15 devices. Accordingly, we are adopting our proposal to permit digital modulation systems to operate under the conditions contained in Section 15.247. Under the new rules, digital modulation systems will be subject to the same power output maximum, 1 Watt, and power spectral density limits, 8 dBm per 3 kHz, as direct sequence spread spectrum systems.

14. In the *Further Notice*, we asked if digital systems could be accommodated by amending the U-NII rules to include the 915 MHz and 2.4 GHz bands as an alternative to regulation under the spread spectrum rules. In response, Intersil suggests that we modify the U-NII band rules to allow for digitally modulated devices at 2.4 GHz.[32] Intersil states that the U-NII band regulations were developed specifically for the operation of digital transmission systems and were intended to provide maximum flexibility. Intersil notes that the U-NII rules have permitted the digital modulation form Orthogonal Frequency Division Multiplexing ("OFDM") to operate in the 5 GHz band. They foresee introduction of more innovative devices such as dual mode OFDM devices that would operate in both the 5 GHz band and 2.4 GHz band. On the other hand, Apple, Silicon Wave, and Intel object to modifying the U-NII rules.[33] They state that such a modification should not be made before conducting a more thorough analysis of the consequences of such action. Specifically, Apple states that the Commission should first identify the exact rule changes and explain what it believes the effect of those changes would be. Accordingly, Apple states that the matter should be left for future consideration. The opposing parties also state that the different operating limits between the spread spectrum rules and the U-NII rules may cause confusion and slow development of products in the 2.4 GHz band. For example, Intel notes that the power spectral density limitation for 2.4 GHz spread spectrum devices is higher than the limits for devices operating under the U-NII rules. Therefore, Intel states that altering the U-NII rules to include the 915 MHz and 2.4 GHz bands could disrupt the use of existing or planned equipment in these bands. Silicon Wave expresses similar concerns.

15. At this time, we decline to modify the U-NII rules to add the 915 MHz and 2.4 GHz bands. We conclude that operation of digital devices in the 915 MHz, 2.4 GHz, and 5.7 GHz bands is best accommodated under the revised Section 15.247 rules for digitally modulated systems. The current emission specifications and operating bands available for U-NII operation were adopted only after an exhaustive rulemaking proceeding which included submission of detailed studies. We have not had the opportunity to examine similar information with regard to other bands. As a consequence of the action we are taking in this proceeding, digital devices will be permitted to operate in the 5.725 – 5.850 GHz band under the Section 15.247 rules as well as in the 5.725 – 5.825 GHz band under the U-NII rules. We expect that manufacturers will examine the different bandwidth requirements of the Section 15.247 rules and the U-NII rules to determine which requirements are best suited for a particular 5.7 GHz digital device.[34]

16. In the *Further Notice*, we also sought comment on whether it would be necessary to make

[32] Intersil comments at page 5.

[33] *See* Apple comments at page 7, Silicon Wave comments at page 9, Intel comments at page 3.

[34] *See supra* note 13 on the U-NII requirements.

any changes in the power level adjustments for point-to-point operation if we were to reduce the allowed power for new digitally modulated systems below 1 Watt. In this Second Report and Order we have determined that digital systems will be allowed to operate at a maximum 1 Watt power output. Therefore, consideration of further power adjustments for point-to-point operations is unnecessary.

B. Processing Gain

17. The rules currently require direct sequence spread spectrum devices to have a processing gain of at least 10 dB.[35] Processing gain represents the improvement to the received signal-to-noise ratio, after filtering to the information bandwidth, from the spreading/dispreading function. The processing gain is also a measure of a direct sequence systems ability to withstand interference. In the *Further Notice* we stated that as the spread spectrum industry has matured, it is not clear that the processing gain requirement continues to be necessary.[36] Manufacturers have an incentive to design their systems to include processing gain in order for their device to operate properly when located near other radio frequency devices. We further noted that it has become increasingly difficult to determine true processing gain of certain direct sequence spread spectrum systems due in part to a diversity of opinion within the industry as to the definition of processing gain for these systems and the proper way to measure it. We also noted that uncertainties about the processing gain requirement can be a significant impediment to the introduction of new technologies. In light of these factors, the *Further Notice* proposed to eliminate the processing gain requirement for direct sequence spread spectrum systems.

18. Parties were divided on whether to remove the processing gain requirement. Adtran, Apple, Cisco Systems, Inc. ("Cisco"), Joint Commenters, OFDM Forum, Silicon Wave, Inc., Western Multiplex Corporation, Wi-LAN, and WCA agree with our assessment that the marketplace will demand that manufacturers design systems with adequate interference rejection and performance, and support the elimination of the processing gain requirement. Apple states that the our digital transmission system proposal obviates the need for the processing gain requirement because a digital transmission system would not be required to spread its signal anyway, and thus the fundamental reason for requiring processing gain disappears.[37] Apple further argues that subverting the processing gain test is not difficult because it is possible to design a device to exhibit processing gain based on a certain test without using a true spread spectrum signal. It states that a Part 15 communications system manufacturer's survival depends in part on the ability to produce devices with low interference potential and high interference resistance. The Joint Commenters state that it is unfair to burden manufacturers with a technical requirement that cannot plainly be shown to accomplish its purpose. They further state that the interference threat of a spread spectrum device depends on how it spreads energy, while processing gain measures how it spreads information.[38] WCA states that the processing gain requirement may actually create an artificial barrier to the introduction of new technologies for users of the 2.4 GHz band.[39] Western Multiplex states that processing gain is an ineffective countermeasure for reuse and interference mitigation and therefore should be abandoned.[40]

19. Agere, Ademco Group ("Ademco"), American Radio Relay League ("ARRL"), and Intersil oppose the elimination of the processing gain requirement. Ademco states that in the unlicensed bands there is a high probability that different types of systems will operate at the same location. It

[35] *See* 47 C.F.R. § 15.247(e).

[36] *See Further Notice* at paragraph 22.

[37] *See* Apple comments at page 9.

[38] *See* Joint Comments at page 5.

[39] *See* WCA at page 3.

[40] *See* Western Multiplex at page 1.

further adds that to ensure communication reliability, interference immunity achieved through processing gain can be traded off against higher transmit power in a direct sequence spread spectrum system design. As a result, Ademco argues, everyone in the unlicensed bands benefits from reduced spectral power density achieved in part by the system benefits provided by processing gain.[41] Ademco states that the continuous wave ("CW") jamming margin method, which is used to demonstrate processing gain, represents a worst-case real-life test and is readily verified.[42] It further states that that if the processing gain requirement is eliminated, the allowable RF power output should also be reduced.[43] Agere states that the CW jammer test, while not perfect, is adequate because it is an established, well-documented method that has not resulted in undue interference problems from direct sequence spread spectrum systems to date. Agere further states that keeping the established requirements and testing procedures for processing gain in place would facilitate the ability of manufacturers to obtain certification on new, lower cost, more highly integrated versions of existing systems, which will benefit consumers.[44] ARRL states that the processing gain requirement gives amateurs some assurance that Part 15 spread spectrum devices will distribute their power uniformly over the bandwidth utilized without spectral lines.[45] ARRL is unconvinced that manufacturers have any incentive to design their systems to include processing gain. Because amateur stations operate in close proximity to residential spread spectrum consumer devices, ARRL is concerned that the elimination of processing gain would reduce the Part 15 receivers' immunity to interference from amateurs' narrowband signals.

20. Consistent with our decision to allow operation of digital modulation systems with spectrum characteristics similar to those of spread spectrum systems, we find that it is no longer desirable to maintain the processing gain requirement for direct sequence systems. The processing gain requirement was incorporated into the rules to ensure that systems taking advantage of the higher power levels afforded spread spectrum systems were indeed direct sequence spread spectrum systems and therefore have some tolerance to interference. We believe that manufacturers have a market-driven incentive to design their systems with the ability to operate properly when located near other radio frequency devices. Ademco's concern that direct sequence spread spectrum systems will trade off interference immunity achieved by processing gain for higher transmit powers is unfounded. As we noted in paragraph 12 herein, the intended application generally dictates the operating power of these devices. Again, we find no evidence to indicate that power levels will increase. Additionally, although processing gain does provide a measure of interference protection, other methods, such as including error correction coding, may also achieve the same result. Systems using some form of error correction may have the same interference immunity as those with processing gain. However, this property may not be verifiable using the current processing gain measurement test. Therefore, we disagree with Ademco and Agere's assertion that the jamming margin method is an adequate measure of system performance. We find no indication that manufacturers will not continue to employ processing gain or error coding to provide the quality of service needed for the effective operation of a particular device. Contrary to Agere's statement, we disagree that retaining processing gain will facilitate manufacturers' ability to certify new products. Instead, we hold that the requirement unnecessarily hinders development of

[41] *See* Ademco at page 2.

[42] *See* 47 C.F.R. § 15.247(e)(2).

[43] *See* Ademco at page 2.

[44] *See* Agere at paras 31-32.

[45] *See* ARRL at page 4.

innovative products.

21. We are not persuaded by ARRL's arguments for preserving the processing gain requirement. First, ARRL presents no evidence that new digital technologies will tend to concentrate emissions in narrow spectral lines causing interference to amateur receivers. On the contrary, these new digital devices will likely be used for high data rate applications where wide bandwidths are preferable. Therefore, amateur receivers should see no increase in narrowband interference. Additionally, ARRL seems concerned that Part 15 receivers without processing gain will be more susceptible to interference from amateur devices. As we stated previously, although manufacturers may design digital systems to trade-off interference immunity and data rates, these new systems should be designed to operate effectively for their intended purposes in the presence of other signals. Accordingly, we will remove the processing gain requirement.

C. Frequency Hopping Spread Spectrum Systems

22. The *First Report and Order* ("*First R&O*") in this proceeding amended the spread spectrum rules to allow frequency hopping spread spectrum systems in the 2.4 GHz band to use bandwidths greater than 1 MHz but equal to or less than 5 MHz at a reduced power output of up to 125 mW.[46] These wideband frequency hopping systems are allowed to use as few as fifteen non-overlapping channels provided that the total span of hopping channels is at least 75 MHz. Frequency hopping systems with a bandwidth of up to 1 MHz were still required to use at least 75 non-overlapping hopping channels. In response to the *First R&O,* thirteen parties filed a Joint Petition for Clarification or, in the Alternative, Partial Reconsideration ("Joint Petition").[47] The Joint Petition requested that the Commission clarify the rules adopted in the *First R&O* to specify a minimum of 15 hopping channels for any system that uses adaptive hopping techniques to avoid operating on occupied frequencies and limits its output power to 125 mW, regardless of hopping channel bandwidth.[48]

23. In the *Further Notice*, we proposed to adopt the changes requested in the Joint Petition. Specifically, we proposed to allow frequency hopping devices in the 2.4 GHz band to use as few as 15 hops, irrespective of the bandwidth utilized. We proposed that a device using the minimum number of hops would have to limit output power to 125 mW and also use adaptive hopping techniques to avoid transmitting on occupied channels, thus reducing the potential to interfere with others. The *Further Notice* invited comment as to whether use of adaptive hopping techniques should be mandatory and how compliance with this requirement should be determined when evaluating specific devices for purposes of equipment certification. Comment was also requested regarding alternative conditions that would provide the flexibility to market new types of frequency hopping devices while keeping interference risks at minimal levels. For example, we asked if the goals could be achieved by requiring that adaptive hopping systems use a minimum amount of bandwidth with a power reduction in relationship to the amount of

[46] *First Report and Order* in ET Docket 99-231, 15 FCC Rcd 16244 (2000).

[47] *Joint Petition For Clarification or, in the Alternative, Partial Reconsideration*, submitted on October 25, 2000, by 3Comm, Apple Computer, Cisco Systems, Dell Computer, IBM, Intel Corporation, Intersil, Lucent Technologies, Microsoft, Nokia Inc., Silicon Wave, Toshiba America Information Systems, and Texas Instruments.

[48] Adaptive hopping is accomplished by the incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the band so that it individually and independently chooses and adapts its hopset to avoid occupied channels.

spectrum used. We also asked if fewer than 15 hops could be used efficiently and effectively with a corresponding reduction in power.

24. The majority of the commenters support the proposal to allow frequency hopping systems to use as few as fifteen hopping channels with output power not exceeding 125 mW.[49] The commenters generally agree that a reduction in maximum allowed power from 1 Watt to 125 mW is an acceptable compromise in exchange for using fewer hopping channels. Proxim alone argues that the Commission has provided no justification to require a power reduction for systems using a reduced hopset.[50] Proxim states that there is no need to treat the 2.4 GHz band differently than the 5.7 GHz band where 1 Watt output power is allowed. Additionally, Proxim notes that some applications that would benefit from using adaptive hopping would be more effective with greater output power.

25. Agere and Silicon Wave support a mandatory adaptive hopping requirement.[51] Agere argues that the public interest objective should be to maximize co-existence among devices in the 2.4 GHz band. Agere believes that the benefits of adaptive hopping techniques in minimizing or eliminating interference is reason enough to require the use of such techniques for systems that employ reduced hopsets and channel bandwidths of 1 MHz or less. Silicon Wave states that, although it generally believes that adaptive hopping implementation should be a choice made by the manufacturer, adaptive hopping should be required for any system that uses a reduced hopset. Other parties state that the proposal to require the use adaptive hopping techniques is overly restrictive and should not be adopted. For example, Texas Instruments asserts that if adaptive hopping were mandatory, other performance standards may also have to be defined, such as how quickly hopsets must change in response to interference or the interference threshold level at which the hopset must change.[52] It submits that, because these conditions may vary from one system to the next, a set of performance standards that is beneficial to the operation of one system may be detrimental to another. Similarly, Apple believes that different devices should be allowed to implement adaptive hopping, as needed, without a Commission mandate.[53]

26. Proxim objects to allowing as few as fifteen hopping channels for systems in the 2.4 GHz band. Proxim believes that this proposal could lead to frequency hopping systems that do not spread their energy through a wide portion of the band, and therefore increase interference potential to other receivers. It points to the 5.7 GHz band and notes that systems operating in that band use up to 60% of the available bandwidth.[54] Proxim proposes that frequency hopping systems in the 2.4 GHz band also be required to use at least 60% of the available band. It contends that the 60% threshold would serve the needs of manufacturers while preserving the underlying sharing philosophy of the Part 15 rules. Ademco also proposes that a minimum amount of bandwidth be used. Although Ademco does support the proposed

[49] *See, e.g.,* comments of Adtran, Inc.; The Wireless Communications Association International; Silicon Wave, Inc.; Wi-LAN, Inc.; WIDCOMM; Agere; Intel Corporation; Bluetooth SIG; Intel Corporation; and Apple Computers. *See also* reply comments of Telecommunications Industry Association.

[50] Proxim comments at page 5.

[51] *See*, *generally*, Agere comments and reply comments and Silicon Wave comments at footnote 3.

[52] Texas Instruments comments at page 4.

[53] *See* Apple comments at page 7.

[54] 125 MHz of spectrum is available at 5.7 GHz. A system using maximum a hopping channel bandwidth of 1 MHz would be required to use 75 MHz, or 60%, of the available spectrum.

reduction in the minimum number of hopping channels, it states that the fifteen channels should be required to be spread over a minimum of 90% of the band.[55] It submits that such a requirement would prevent any segment of the 2.4 GHz band from being over used.

27. We will allow frequency hopping spread spectrum systems to use as few as fifteen hopping channels with bandwidths up to 5 MHz and no minimum band occupancy requirements, provided output power is reduced to 125 mW. This modification of our regulations for frequency hopping systems will provide greater flexibility without significantly increasing the risk of interference to other users. In the *First R&O* in this proceeding, we determined that frequency hopping systems with bandwidths between 1 MHz and 5 MHz may operate in the 2.4 GHz band with a minimum of 15 hopping channels and 125 mW output power with minimal interference potential.[56] Nothing in the record of this proceeding demonstrates that frequency hopping systems with bandwidths of 1 MHz or less cannot also operate effectively with a minimum of fifteen hopping channels with a similar power reduction. The reduction of maximum peak power from 1 Watt to 125 mW will offset any increased potential for interference caused by use of the reduced hopset, regardless of channel bandwidth. In addition, we find it unnecessary to require frequency hopping systems to occupy a minimum percentage of the 2.4 GHz band as Proxim and Ademco suggest. Our primary concern for the operation of devices in the 2.4 GHz band is interference avoidance. Although a minimum bandwidth occupancy requirement may, in some cases, reduce the interference potential of frequency hopping systems, it is not the only method by which the systems can efficiently share the band. Indeed, such a requirement may actually negate the possibility for system designers to implement more efficient spectrum sharing techniques as they see fit. The simple, unambiguous rules we are adopting in this Second Report and Order will allow manufacturers the freedom to design an array of frequency hopping systems that effectively share the 2.4 GHz band.

28. We will not require frequency hopping systems that use a reduced hopset to employ adaptive hopping techniques. We agree with those parties who contend that the power reduction we are adopting for these devices is sufficient to mitigate any possible increase in interference potential due to the smaller number of hopping channels. Furthermore, operation pursuant to the modified rules will not pose a greater interference threat than systems authorized under our former rules.[57] We also note that Section 15.247(h) of the rules permits the use of intelligent or adaptive hopping techniques in order to avoid transmitting on occupied frequencies.[58] We believe that Section 15.247(h) provides sufficient flexibility for manufacturers to design products which incorporate adaptive hopping in circumstances where it would be beneficial. For example, the amended rules would permit manufacturers to build products that include adaptive techniques such as a product that includes both a digital and a frequency hopping transmitter, where the frequency hopping transmitter avoids or suppresses its transmissions when the digital transmitter is operating.

D. Other Issues

[55] *See* Ademco comments at page 1.

[56] *See First Report and Order* at paragraph 15.

[57] *See* 47 C.F.R. § 15.247(a)(1)(iii). The rules allowed frequency hopping systems to use as few as fifteen hopping channels provided the total span of hopping channels was at least 75 MHz. These systems were not required to incorporate adaptive hopping techniques.

[58] 47 C.F.R. § 15.247(h).

29. Sirius Satellite Radio Inc. ("Sirius") filed comments and XM Radio Inc. ("XM") filed reply comments that address the out-of-band emission limits for Part 15 devices. Sirius and XM hold licenses to provide satellite digital audio radio service ("SDARS") in the 2310 – 2360 MHz band. They contend that the Commission's regulations, which limit out-of-band emissions from devices operating in the 2.4 GHz band to 500 uV/m as measured at 3 meters, are insufficient to protect SDARS receivers from experiencing interference from Part 15 transmitters.[59] Sirius asserts that out-of-band emissions from 2.4 GHz devices should be limited to 14.6 dB uV/m at 3 meters for a single Part 15 device and 18.6 dBuV/m at 3 meters for multiple Part 15 devices operating within a given area.

30. The adequacy of the current out-of band emission limits applicable to Part 15 spread spectrum devices operating in the 2.4 GHz band is beyond the scope of this proceeding. We initiated this proceeding in 1999 in an effort to facilitate continued development and deployment of spread spectrum technology.[60] At no time has out-of-band emission limits been at issue. Hence, no record on Sirius' proposal has been established in the docket of this proceeding. Furthermore, Sirius does not provide sufficient information for the Commission or interested parties to evaluate the validity of its claims. For example, Sirius does not identify the basis of its proposed out-of-band emission limits, and it fails to address implementation or enforcement aspects of its proposal. If Sirius wishes the Commission to give its concerns full consideration it may file appropriate documentation with the Commission detailing its interference claims and describing what action might be appropriate to ameliorate such interference. However, we will not act on this matter herein.

PROCEDURAL MATTERS

31. Final Regulatory Flexibility Analysis. The Final Regulatory Flexibility Analysis, required by the Regulatory Flexibility Act, *see* 5 U.S.C. § 604, is contained in Appendix C.

ORDERING CLAUSES

32. Accordingly, IT IS ORDERED that Part 2 and Part 15 of the Commission's Rules ARE AMENDED as specified in Appendix B. This action is taken pursuant to the authority contained in Sections 4(i), 301, 302, 303(e), 303(f), and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 301, 302, 303(e), 303(f), and 303(r).

[59] *See* 47 C.F.R. §15.209.

[60] *See Notice of Proposed Rule Making*, ET Docket 99-231, 14 FCC Rcd 13046 (1999).

33. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this Second Report and Order, including the Final Regulatory Flexibility Act, to the Chief, Counsel for Advocacy of the Small Business Administration.

34. IT IS FURTHER ORDERED that this proceeding IS TERMINATED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Comments

1. Ademco Group
2. Adtran, Inc.
3. Agere Systems
4. American Radio Relay League
5. Apple Computer, Inc.
6. Axonn, LLC
7. Bluetooth SIG, Inc.
8. Bret Boren
9. Cisco Systems, Inc.
10. IEEE Project 802™, Local and Metropolitan Area Networks Standards Committee
11. Intel Corporation
12. Intersil Corporation
13. Joint Comments of 3Com Corporation; Clearwire Technologies, Inc.; InterWAVE Communications, Inc.; LinCom Wireless, Inc.; Symbol Technologies, Inc.; VOCOLLECT, INC.
14. Peter Nurse, OFDM Forum
15. Proxim, Inc.
16. Silicon Wave, Inc.
17. Sirius Satellite Radio Inc.
18. Texas Instruments Incorporated
19. The Wireless Communications Association International, Inc.
20. The Wireless Ethernet Compatibility Alliance
21. Western Multiplex Corp.
22. WIDCOMM
23. Wi-LAN, Inc.

Reply Comments

1. Agere Systems
2. Alvarion Ltd.
3. Apple Computer, Inc.
4. Axonn, LLC
5. Information Technology Industry Council (ITI)
6. Intersil Corporation
7. Joint Reply Comments of 3Com Corporation; Clearwire Technologies, Inc.; InterWAVE Communications, Inc.; LinCom Wireless, Inc.; Symbol Technologies, Inc.; and VOCOLLECT, INC.
8. Proxim, Inc.
9. Silicon Wave, Inc.
10. Telecommunications Industries Association (TIA)
11. Texas Instruments Incorporated
12. Wireless Communications Association International, Inc.
13. XM Radio, Inc.

APPENDIX B

For the reasons set forth above, Parts 2 and 15 of Title 47 of the Code of Federal Regulations is amended as follows:

PART 2 – FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS

1. The authority citation for Part 2 continues to read as follows:

Authority: 47 U.S.C. 154, 302a, 303, and 336, unless otherwise noted.

2. Section 2.1033 is amended by removing paragraph (b)(10) and re-designating paragraphs (b)(11) and (b)(12) as (b)(10) and (b)(11), respectively.

PART 15 – RADIO FREQEUNCY DEVICES

3. The authority citation for Part 15 continues to read as follows:

Authority: 47 U.S.C. 154, 302, 303, 304, 307, and 544A.

4. Section 15.247 is amended as by revising paragraphs (a), (a)(1)(ii), (a)(1)(iii), (a)(2), (b)(1), (c), and (d); re-designating paragraphs (b)(3) and (b)(4) as (b)(4) and (b)(5), respectively; adding a new paragraph (b)(3); re-designating paragraph (e) as reserved; and revising paragraph (f).

Section 15.247 **Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.**

(a) Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) * * *

(i) * * *

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400 - 2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems which use fewer than 75 hopping frequencies may employ intelligent hopping techniques to avoid interference to other transmissions. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 non-overlapping channels are used.

(2) Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

(b) * * *

(1) For frequency hopping systems in the 2400 -2483.5 MHz band employing at least 75 hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 Watt. For all other frequency hopping systems in the 2400 - 2483.5 band: 0.125 Watt

(2) * * *

(3) For systems using digital modulation in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands: 1 Watt.

(4) Except as shown in paragraphs (b)(4)(i), (ii), and (iii) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (b)(4)(i) and (b)(4)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(5) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. *See* § 1.1307(b)(1) of this Chapter.

(c) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power than is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

(d) For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

(e) Reserved

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall comply with the power density requirements of paragraph (d) of this section.

(g) * * *

(h) * * *

NOTE: * * *

APPENDIX C

Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act ("RFA"),[61] an Initial Regulatory Flexibility Analysis ("IRFA") was incorporated in the *Further Notice of Proposed Rule Making* ("*Further Notice*") in this docket, ET Docket 99-231.[62] The Commission sought written public comment on the proposals in the *Further Notice*, including comment on the IRFA. As described more fully below, we find that the rules we adopt in the Second Report and Order will not have a significant economic impact on a substantial number of small entities.[63] We have nonetheless provided this Final Regulatory Flexibility Analysis ("FRFA") to provide a fuller record in this proceeding. This FRFA conforms to the RFA.[64]

A. Need for and Objective of the Rules.

The Commission's spread spectrum rules have been a tremendous success. A wide variety of devices have been introduced under these rules for business and consumer use including cordless telephones and computer local area networks. Moreover, the past few years have witnessed the development of industry standards, such as IEEE 802.11b, Bluetooth, and Home RF, that promise to greatly expand the number and variety of devices that will operate in the 2.4 GHz band. We anticipate the introduction of wireless headsets and computer connections for cellular and PCS phones, wireless computer peripherals such as printers and keyboards, and a host of new wireless Internet appliances that will use this band.

The rules adopted in this Second Report and Order provide for the introduction of new digital transmission technologies, eliminate unnecessary regulations for spread spectrum systems, and improve spectrum sharing by unlicensed devices operating in the 915 MHz (902 - 928 MHz), 2.4 GHz (2400 - 2483.5 MHz), and 5.7 GHz (5725 – 5850 MHz) bands. Specifically, this Second Report and Order revises Section 15.247 of the Commission's rules to allow new digital transmission technologies and direct sequence spread spectrum systems to operate under the same rules in the 915 MHz, 2.4 GHz, and 5.7 GHz bands.[65] We also remove the requirement that direct sequence spread spectrum systems must demonstrate at least 10 dB of processing gain. Finally, this Second Report and Order modifies the rules for frequency hopping spread spectrum systems operating in the 2.4 GHz band to reduce the amount of spectrum that must be used with certain types of operation. We take these actions to facilitate the continued development and deployment of new wireless devices for businesses and consumers.

[61] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601 - 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[62] *See* ET Docket 99-231, FCC 01-158, 66 Fed. Reg. 31585 (2001).

[63] Thus, we could certify that an analysis is not required. *See* 5 U.S.C. § 605(b).

[64] *See* 5 U.S.C. § 604.

[65] 47 C.F.R. § 15.247

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA.

Only the Information Technology Industry Council ("ITI") filed comments in response to the IRFA.[66] ITI supports the Commission's proposal. They state that the proposals contained in the *Further Notice of Proposed Rule Making* will significantly improve sharing of the spectrum by wireless devices operating in the 2.4 GHz band.

ITI supports the proposal to modify Section 15.247 of the Commission's rules governing frequency hopping spread spectrum devices in the 2.4 GHz band to allow as few as fifteen hopping channels. However, ITI requests that the Commission consider further modifications to permit even fewer than fifteen channels. It states that wireless devices using less than fifteen channels can be designed not to interfere with other equipment. It further states that adopting a minimum limit of hopping channels is contrary to the Commission's intent to improve flexibility for manufacturers an does not contribute to additional clarifying rulemakings.

ITI also supports the Commission's other proposals. Specifically, ITI urges the Commission to modify its rules to accommodate new digital modulation systems in the 915 MHz, 2.4 GHz, and 5.7 GHz bands. It states that the changes will provide manufacturers with flexibility to design non-interfering products for these bands without the need for frequent rule changes to address each new technology. Finally, ITI supports the proposal to remove the requirement that direct sequence spread spectrum systems must demonstrate at least 10 dB of processing gain. It states that the requirement is no longer necessary since manufacturers have an incentive to include processing gains to ensure that their devices operate properly when located near other radio frequency devices.

C. Description and Estimate of the Number of Small Entities to Which the Rules Will Apply.

The RFA directs agencies to provide a description of, and, where feasible, an estimate of the number of small entities that may be affected by the rules adopted herein.[67] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdictions."[68] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[69] A "small business concern" is one that: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) meets any additional criteria established by the Small Business Administration ("SBA").[70]

The Commission has not developed a definition of small entities specifically directed toward

[66] *See* Information Technology Industry Council comments.

[67] 5 U.S.C. § 604(a)(3).

[68] 5 U.S.C. § 601(6).

[69] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

[70] 15 U.S.C. § 632.

manufacturers of unlicensed communications devices. Therefore, we will utilize the SBA definition applicable to manufacturers of Radio and Television Broadcasting and Communications Equipment. According to the SBA regulations, unlicensed transmitter manufacturers must have 750 or fewer employees in order to qualify as a small business concern.[71] Census Bureau data indicates that there are 858 U.S. companies that manufacture radio and television broadcasting and communications equipment, and that 778 of these firms have fewer than 750 employees and would be classified as small entities.[72] This action will not have a negative impact on small entities that manufacture unlicensed spread spectrum devices.

According to SBA regulations, an electronic computer manufacturer must have 1,000 or fewer employees in order to qualify as a small entity.[73] Census Bureau data indicates that there are 716 firms that manufacture electronic computers. Of those, 659 have fewer than 500 employees and qualify as small entities.[74] The remaining 57 firms have 500 or more employees; however, we unable to determine how many of those have 1,000 or fewer employees and therefore also qualify as small entities under the SBA definition.

According to SBA regulations, a computer terminal manufacturer must have 1,000 or fewer employees in order to qualify as a small entity.[75] Census Bureau data indicates that there are 757 firms that manufacture computer terminals. Of those, 162 have fewer than 500 employees and qualify as small entities.[76] The remaining 11 firms have 500 or more employees; however, we unable to determine how many of those have 1,000 or fewer employees and therefore also qualify as small entities under the SBA definition.

According to SBA regulations, a computer peripheral equipment manufacturer must have 1,000 or fewer employees in order to qualify as a small entity.[77] Census Bureau data indicates that there are 757 firms that manufacture computer terminal equipment. Of those, 701 have fewer than 500 employees and qualify as small entities.[78] The remaining 56 firms have 500 or more employees; however, we unable to

[71] *See* 13 C.F.R. § 121.201, (NAICS) Code 334220.

[72] *See* U.S. Dept. of Commerce, *1992 Census of Transportation, Communications and Utilities* (issued May 1995), NAICS Code 334220.

[73] 13 C.F.R. 121.201, NAICS Code 334111.

[74] U.S. Small Business Administration 1995 Economic Census Industry and Enterprise Report, Table 3, NAICS Code 334111. (Bureau of the Census data adapted by the Office of Advocacy of the U.S. Small Business Administration).

[75] 13 C.F.R. 121.201, NAICS Code 334111.

[76] U.S. Small Business Administration 1995 Economic Census Industry and Enterprise Report, Table 3, NAICS Code 334111. (Bureau of the Census data adapted by the Office of Advocacy of the U.S. Small Business Administration).

[77] 13 C.F.R. 121.201, NAIC Code 334119.

[78] U.S. Small Business Administration 1995 Economic Census Industry and Enterprise Report, Table 3, NAICS Code 334119. (Bureau of the Census data adapted by the Office of Advocacy of the U.S. Small Business Administration).

determine how many of those have 1,000 or fewer employees and therefore also qualify as small entities under the SBA definition.

According to SBA regulations, a manufacturer of household appliances must have 500 or fewer employees in order to qualify as a small entity.[79] Census bureau indicates that there are 55 firms that manufacture household equipment in the "catch all" category for such data. Of those, 42 have fewer than 500 employees and qualify as small entities.[80] The remaining 13 firms have 500 or more employees, and therefore, unless one or more has exactly 500 employees do not qualify as small entities under the SBA definition.

D. Description of Projected Reporting, Recordkeeping and Other Compliance Requirements.

Part 15 transmitters are already required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation. See 47 C.F.R. §§ 15.101, 15.201, 15.305, and 15.405. The new regulations will add permissible methods of operation for frequency hopping spread spectrum systems and permit systems that use digital modulation techniques to operate in the bands formerly reserved for spread spectrum operation. No new reporting or recordkeeping requirements will be required for the manufacturers of frequency hopping spread spectrum devices or systems using digital modulation.

This Second Report and Order removes the requirement that direct sequence spread spectrum systems exhibit a minimum 10 db of processing gain. Therefore, manufacturers will no longer be required to test products and submit confirmation of compliance with this regulation.

E. Steps Taken To Minimize Significant Economic Impact on Small Entities and Significant Alternatives Considered.

The rule modifications made in this Second Report and Order will facilitate the continued development and deployment of new wireless devices for business and consumers. These actions will benefit manufacturers of digitally modulated unlicensed devices and direct sequence and frequency hopping spread spectrum devices, including small entities.

In the *Further Notice*, we proposed to amend Section 15.247 of the Commission's rules to provide for the use of systems which use new digital modulation technologies. Specifically, we proposed to allow these devices to operate in the 915 MHz, 2.4 GHz, and 5.7 GHz bands under the same technical requirement as spread spectrum systems. We invited comment on whether these technologies should be allowed to operate at the same power levels as direct sequence spread spectrum systems, specifically 1 Watt maximum output power with a maximum power spectral density of 8 dBm per 3 kHz. We also noted that the proposals for new digital devices are similar to the rules for Unlicensed National Information Infrastructure (U-NII) devices contained in Subpart E of Part 15, and sought comment on whether these new digital technologies could be accommodated under those rules.

Based on analysis of the record, including comments from small business concerns, we have concluded

[79] 13 C.F.R. 121.201, NAICS Code 333298.

[80] U.S. Small Business Administration 1995 Economic Census Industry and Enterprise Report, Table 3, NAICS 333298 (Bureau of the Census data adapted by the Office of Advocacy of the U.S. Small Business Administration).

that systems using digital modulation technologies may operate in the 915 MHz, 2.4 GHz, and 5.7 GHz bands under the same rules as direct sequence spread spectrum devices without posing a risk of creating additional interference. We declined to regulate these devices under an alternative set of rules.

The *Further Notice* also proposed to remove the requirement that direct sequence spread spectrum systems demonstrate a minimum of 10 dB of processing gain. One alternative the Commission considered was to decline to remove the requirement. However, we determined that retaining the requirement would unnecessarily hinder the introduction of new non-interfering devices in the bands.

The *First Report and Order* ("*First R&O*") in this proceeding amended the spread spectrum rules to allow frequency hopping spread spectrum systems in the 2.4 GHz band to use bandwidths greater than 1 MHz but less than 5 MHz at a reduced power output of up to 125 mW.[81] These wideband frequency hopping systems are allowed to use as few as fifteen non-overlapping channels provided that the total span of hopping channels is at least 75 MHz. Frequency hopping systems with a bandwidth of up to 1 MHz were still required to use at least 75 non-overlapping hopping channels. In response to the *First R&O,* thirteen parties filed a Joint Petition for Clarification or, in the Alternative, Partial Reconsideration ("Joint Petition").[82] The Joint Petition requested that the Commission clarify the rules adopted in the *First R&O* to specify a minimum of 15 hopping channels for any system that uses adaptive hopping techniques to avoid operating on occupied frequencies and limits its output power to 125 mW, regardless of hopping channel bandwidth.[83] In the *Further Notice*, we proposed to adopt the changes requested in the Joint Petition.

The majority of the commenters support the proposal to allow frequency hopping systems to use as few as fifteen hopping channels with output power not exceeding 125 mW.[84] The commenters generally agree that a reduction in maximum allowed power from 1 Watt to 125 mW is an acceptable compromise in exchange for using fewer hopping channels.

Proxim objects to allowing as few as fifteen hopping channels for systems in the 2.4 GHz band. Proxim believes that this proposal could lead to frequency hopping systems that do not spread their energy through a wide portion of the band, and therefore increase interference potential to other receivers. It points to the 5.7 GHz band and notes that systems operating in that band use up to 60% of the available bandwidth.[85] Proxim proposes that frequency hopping systems in the 2.4 GHz band also be required to

[81] *First Report and Order* in ET Docket 99-231, 15 FCC Rcd 16244 (2000).

[82] *Joint Petition For Clarification or, in the Alternative, Partial Reconsideration*, submitted on October 25, 2000, by 3Comm, Apple Computer, Cisco Systems, Dell Computer, IBM, Intel Corporation, Intersil, Lucent Technologies, Microsoft, Nokia Inc., Silicon Wave, Toshiba America Information Systems, and Texas Instruments.

[83] Adaptive hopping is accomplished by the incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the band so that it individually and independently chooses and adapts its hopset to avoid occupied channels.

[84] *See, e.g.,* comments of Adtran, Inc.; The Wireless Communications Association International; Silicon Wave, Inc.; Wi-LAN, Inc.; WIDCOMM; Agere; Intel Corporation; Bluetooth SIG; Intel Corporation; and Apple Computers. *See also* reply comments of Telecommunications Industry Association.

[85] 125 MHz of spectrum is available at 5.7 GHz. A system using maximum a hopping channel bandwidth of 1 MHz would be required to use 75 MHz, or 60%, of the available spectrum.

use at least 60% of the available band. It contends that the 60% threshold would serve the needs of manufacturers while preserving the underlying sharing philosophy of the Part 15 rules. Ademco also proposes that a minimum amount of bandwidth be used. Although Ademco does support the proposed reduction in the minimum number of hopping channels, it states that the fifteen channels should be required to be spread over a minimum of 90% of the band.[86] It submits that such a requirement would prevent any segment of the 2.4 GHz band from being over used.

We will allow frequency hopping spread spectrum systems to use as few as fifteen hopping channels with bandwidths up to 5 MHz and no minimum band occupancy requirements, provided output power is reduced to 125 mW. This modification of our regulations for frequency hopping systems will provide greater flexibility without significantly increasing the risk of interference to other users. The reduction of maximum peak power from 1 Watt to 125 mW will offset any increased potential for interference caused by use of the reduced hopset, regardless of channel bandwidth. In addition, we find it unnecessary to require frequency hopping systems to occupy a minimum percentage of the 2.4 GHz band as Proxim and Ademco suggest. Our primarily concern for the operation of devices in the 2.4 GHz band is interference avoidance. Although a minimum bandwidth occupancy requirement may, in some cases, reduce the interference potential of frequency hopping systems, it is not the only method by which the systems can efficiently share the band. Indeed, such a requirement may actually negate the possibility for system designers to implement more efficient spectrum sharing techniques as they see fit. The simple, unambiguous rules we are adopting in this Second Report and Order will allow manufacturers the freedom to design an array of frequency hopping systems that effectively share the 2.4 GHz band.

We will not require frequency hopping systems that use a reduced hopset to employ adaptive hopping techniques. We agree with those parties who contend that the power reduction we are adopting for these devices is sufficient to mitigate any possible increase in interference potential due to the smaller number of hopping channels. Furthermore, operation pursuant to the modified rules will not pose a greater interference threat than systems already authorized under our rules.[87] We also note that Section 15.247(h) of the rules permits the use of intelligent or adaptive hopping techniques in order to avoid transmitting on occupied frequencies.[88] We believe that Section 15.247(h) provides sufficient flexibility for manufacturers to design products which incorporate adaptive hopping in circumstances where it would be beneficial. For example, in accordance with the rules, manufacturers may design devices that incorporate both a frequency hopping spread spectrum transmitter and a digital modulation transmitter. Each transmitter must individually comply with applicable rules. However, the frequency hopping transmitter may adapt its hopset in order to avoid causing interference to the digital modulation transmitter.

Report to Congress. The Commission will send a copy of the Second Report and Order, including this FRFA, in a report to Congress pursuant to the Congressional Review Act.[89] In addition, the Commission will send a copy of the Second Report and Order, including the FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Second Report and Order and FRFA (or summaries thereof) will also be

[86] *See* Ademco comments at page 1.

[87] *See* 47 C.F.R. § 15.247(a)(1)(iii). The rules allow frequency hopping systems to use as few as fifteen hopping channels provided the total span of hopping channels is at least 75 MHz. These systems are not required to incorporate adaptive hopping techniques.

[88] 47 C.F.R. § 15.247(h).

[89] *See* 5 U.S.C. § 801(a)(1)(A).

published in the Federal Register.[90]

[90] *See* 5 U.S.C. § 605(b).

SEPARATE STATEMENT OF
COMMISSIONER KEVIN J . MARTIN

Re: *Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices*, Second Report and Order, ET Docket No. 99-231

I am pleased to join in approving this item, which amends our Part 15 rules to enable the introduction of new technologies and allow for more flexibility in design for systems operating in the unlicensed bands. Among other things, this item allows new digital transmission technologies to operate under the current rules for spread spectrum systems and provides new flexibility for frequency hopping spread spectrum systems in the 2.4 GHz band. These actions will further promote the already impressive development of devices and services in the unlicensed bands.

Increased spectral efficiency – particularly through spectrum sharing – is becoming more and more important as we face ever increasing demands for spectrum. I have thus encouraged the Commission to move toward policies that enable and encourage sharing. Our Part 15 rules have been a huge success in that regard, allowing applications such as Bluetooth and 802.11 to flourish by sharing spectrum.

Today's item continues this trend and enables new and better means of spectrum sharing in the unlicensed bands. For example, the item permits the use of as few as fifteen hopping channels for frequency hopping spread spectrum systems, allowing these systems to better avoid occupied channels and thereby evade interference. I am optimistic that this change and the other modifications we make in this item will encourage even greater sharing and result in a more diverse set of products to operate in the unlicensed bands.